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JOHN MASON CLARKE (1857–1925)

WITH the passing of John Mason Clarke, of Albany, on May 29, 1925, the world has lost not only one of its leading paleontologists, but one of its great men of all science. No paleontologist excelled him in discernment of the morphology of invertebrate Paleozoic fossils or in knowledge of the Devonian of North and South America; no philosopher has ever seen more clearly the lessons that these fossils teach or expressed them in more beautiful diction.

Clarke was born in the beautiful lake resort of Canandaigua, New York, on April 15, 1857. He was of old American stock, with the best of traditions. His father, Noah Turner Clarke, one of the pioneers of Naples, New York, and for fifty years teacher and principal in the academy at Canandaigua, was a descendant of the William Clarke who settled at Dorchester, Massachusetts, in 1663, and became later one of the founders of Northampton. His great-grandfather was a member of the Continental Congress and fought throughout the Revolutionary War. His mother was Laura Mason Merrill, of Castleton, Vermont, a descendant of the Mayflower Company, and of Governor Jonathan Trumbull, of Connecticut.

Clarke's love for nature was inborn, and from his earliest boyhood he was interested in the rocks around his home. His first geology in school he got from his father, who then sent him in 1873 to Amherst, where he came under the inspiration of that devoted teacher, B. K. Emerson. He was given the bachelor's degree in 1877, at the age of twenty. The following two years he assisted his father at the Canandaigua Academy, teaching Latin, mathematics and geology, using Dana's text-book in the last-named subject. In 1879–1880 he returned to Amherst as assistant to Emerson. During the school year 1880–1881, he taught in the Free Academy at Utica, where James D. Dana and G. H. Williams had preceded him. Through Emerson's efforts he was in 1881 appointed to teach geology and mineralogy at Smith College, holding this position until the close of the school year 1883. He was then given leave of absence to study toward a doctorate at Göttingen, under Professor von Koenen, and here he spent parts of two years. Returning to Smith in October, 1884, he remained there until the spring of 1885, when he became lecturer on geology, zoology and German at the Massachusetts Agricultural College. Then followed some months of waiting, spent at Canandaigua, where he continued

to work on the Upper Devonian (mainly the Naples fauna), a study begun in the summer of 1877 and intended as his dissertation at Göttingen. Out of employment, he appealed for work to James Hall, whom he had known since 1878. His persistence was rewarded when, on January 2, 1886, he became assistant to the man who was then the master paleontologist of the country. From that day until his death, Clarke was connected with the Geological Survey of New York, rising to the position of state paleontologist in 1898, and in 1904 to that of state geologist and paleontologist and director of the state museum and of the science division of the education department. From 1894 on he was also professor of geology and mineralogy at the Rensselaer Polytechnic Institute in Troy.

Clarke is survived by his wife, formerly Mrs. Fannie V. Bosler, of Philadelphia; by Noah T. Clarke, a son by his first wife, who was Mrs. Emma Sill, of Albany; by two stepdaughters, Mrs. Edith (Sill) Humphrey and Miss Marie Bosler, and a stepson, Mr. Frank N. Sill. Of his brothers and sisters there remain Miss Clara Mason Clarke, who, with Mr. S. Merrill Clarke, a former editor of the New York *Sun*, is still living at Canandaigua; Rev. Lorenzo Mason Clarke, pastor of the First Presbyterian Church in Brooklyn; and Mr. William B. Clarke, managing editor of the Baltimore *American*.

Clarke had a brilliant, alert and well-trained mind. He was elegant in manner and dress and eloquent in speech. As a hard worker he quickly became a prodigious producer of excellent paleontologic and stratigraphic results. Ambitious, perhaps unduly suspicious at times, strong in likes and dislikes, he was also quick-tempered, though he usually had all these traits under good control. In temperament he was a lover of the worth-while and beautiful in nature and in art, and these inborn qualities, with his wide experience, enhanced his ability and eloquence and made him a collector of antique ceramics and furniture and historian of the fisher-folk of Quebec. The same qualities also are reflected in the unusual character of the splendid museum which he developed.

After five summers' work in the field, Clarke began to show results, and his first papers appeared in 1882. They have to do with a rare living molluscan genus, and with rare Crustacea, phyllocarids and barnacles from the New York Devonian. Arthropods were, therefore, his first love among fossils, and they always had for him a dominating interest. In these papers he burst upon the scientific world, as it were, as a full-fledged descriptive paleontologist, since they show nothing of the beginner; even then he wrote well in a clear and direct fashion that, however, as yet showed none of the quaintness of phrase-making, love of strange words and power of embellishment and atmosphere so characteristic of his later writings.

With Clarke's appointment to the New York Survey, his career as a paleontologist and stratigrapher was assured, and from his head and hand there came a continuous stream of the best kind of geologic publications, the great bulk of which were issued by his native state. As yet there is no completed list of his works, but Nickles's "Geologic Literature of North America" gives 192 titles. He must have to his credit more than 250 notes, papers and books, but even this statement does not indicate the volume of his work. A provisional tabulation shows upward of 9,000 pages of printed matter, in which he is godfather to 125 new genera and 865 new species.

Clarke was born on Devonian rocks, and they ever remained the magnet of his endeavors. "The work of a geologist is preeminently what his environment makes it." The strongest pulls were those exerted by the Devonian of New York, southeastern Quebec and Brazil, but he was also attracted by that of Germany, Maryland, Falkland and Argentina. At least one half and probably three fourths of his total output has to do with the paleontology, stratigraphy and mapping of this period. He long ago became one of the two greatest world authorities on the Devonian, the other being Emanuel Kayser, of Germany. Clarke's study of the Upper Devonian faunas of Iberg in that country was written at Göttingen while a student of Von Koenen, and it was at this time that he became acquainted with Kayser. His loyalty to these two teachers of his is shown in his contributions to their *Festschriften:* "Evidences of a Coblenzian invasion in the Devonic of eastern North America" to that of Von Koenen in 1907, and to that of Kayser eight years later, "Conceptions regarding the American Devonic."

The milestones in Clarke's scientific career as shown in his writings are twelve in number. Four of these have to do with stratigraphy and faunal studies (1, 3, 5, 6), three with the morphology of fossils (2, 4, 8), three with the philosophy of fossils (7, 9, 11) and two with history (10, 11). It is not possible here adequately to analyze the significance of these works, and all that can be done is to list them. They are as follows:

(1) The Hercynian question (1889, 1891).

(2) An introduction to the study of the genera of Paleozoic Brachiopoda (with Hall) (1893–1894).

(3) The stratigraphic and faunal relations of the Oneonta, Ithaca and Portage groups in central New York (1897).

(4) A memoir on the Paleozoic reticulate sponges (with Hall) (1898).

(5) The Naples fauna in western New York (1899, 1904).

(6) Early Devonic history of New York and eastern North America (1908, 1909).

(7) Address of the president of the Paleontological Society (1911).

(8) The Eurypterida of New York (with Ruedemann) (1912).

(9) The philosophy of geology and the order of the state (1917).

(10) James Hall of Albany (1921).

(11) Organic dependence and disease (1908, 1921).

(12) L'Île Percée, the finial of the St. Lawrence, or Gaspé Flaneries (1923).

In the early summer of 1900 Clarke was not well, and he needed an outdoor change, and one that would take him away from his scene of action. At that time, he and Schuchert were involved with H. S. Williams in the controversy as to the boundary between Silurian and Devonian, and the New York State Survey and the U. S. National Museum arranged to send both of them to see the most perfect sections of these two periods, those of the eastern Maritime Provinces of Canada. Together they visited the coast of Arisaig, then Dalhousie, Percé and finally Gaspé. Soon Clarke told Schuchert that he had found in Gaspé the hobby that he had long been looking for—a land of quaintness that reminded him somewhat of Scotland, the Old Red, and Hugh Miller, the land of fish, both fossil and recent. In the end Clarke got this entire Devonian problem to work out. The geological results, his *magnum opus*, were published in his two-volume "Early Devonic History of New York and Eastern North America," in 1908–1909. Summer after summer Clarke returned to Gaspé, and in the course of time he became the protector of its seabirds and the historian of this land discovered so early by Jacques Cartier, his affection for it finding expression in "Sketches of Gaspé" (1908), "The Heart of Gaspé" (1913), and "L'Île Percée" (1923). This is a side of Clarke little known to geologists, but one that endeared him to the simple *habitants* of the peninsula.

Gaspé also aroused in Clarke an interest in ceramics, and he published a number of articles on this subject, the most important of which are "English gold lusters" and "The Swiss influence on the early Pennsylvania slip decorated majolica," both privately printed at Albany in 1908.

Clarke's strong historical sense is again seen in his placing of memorial tablets. This began in 1901, when he and a few others placed on the home of Ebenezer Emmons in Albany a tablet commemorating the fact that in this house in 1838–1839 was started the American Association for the Advancement of Science. In 1908 he placed one in Letchworth Park along the upper Genesee to commemorate the first geologic work done by James Hall in western New York in 1839–1843. Five years later, through his efforts, Logan Park was set aside in Gaspé, and here he unveiled before the geologists of the Twelfth International Geological Congress a bronze tablet memorializing Sir William Logan's first field work in eastern Canada. In 1915, at the meeting of the state geologists, a memorial tablet was placed on Hall's private museum in Beaver Park in Albany. The grandest memorial of all, however, was to be unveiled this coming autumn in front of the old Albany Institute—a large bronze statue of Joseph Henry, the first secretary of the Smithsonian Institution, who was a native of Albany. Clarke started the movement for this memorial in 1916, raising $25,000, and he was to have made the unveiling speech; the chairman of the committee which was in charge of the ceremonies has since stated that it had been his intention to make the occasion also the apotheosis of Clarke himself.

Clarke was always much interested in the welfare of the city of Albany. Here he did much to rehabilitate the Albany Institute, one of the oldest scientific societies of the country, and had been its president for many years at the time of his death; helped and cheered on the good work of the ladies of the Dana Natural History Society; had been a trustee of the Dudley Observatory since 1916; and was on the local (and national) council of Boy Scouts, where he arranged for the Mayflower Medal to be awarded each year to the scout having the best knowledge of the local history.

Clarke's championship of the cause of scenic beauty is exemplified in the case of Niagara Falls. The "Menace to Niagara," due to the threat of the power companies to take away, if not all, at least much of the beauty of the falls, was long seen coming, and the fight against it culminated in the New York Assembly in 1904. Clarke stood out against this menace, and in public addresses and otherwise pointed out that "the conservation of Niagara Falls is a question of public morals," since about 800,000 tourists visit the Falls each year and their number demonstrates "how closely the interest of the whole world is focused on Niagara, for these visitors are representatives of every nation. How many hundreds of thousands will seek out Niagara when the world learns that the Delilah of commerce has shorn it of its glory? Will they traverse the seas to behold the wonders of a breakfast-food factory or any other industrial triumph? These are everywhere; Niagara is unique." This battle was won, and a treaty has been made with

Great Britain by which the water of the Falls is kept under reasonable control.

The State Cabinet of New York had its origin in 1843, but it can not be said to have amounted to much until James Hall was placed in charge of it in 1866. In 1904 Clarke was made director of the science division and of the New York State Museum, the successor to the State Cabinet. Three years later Clarke helped in the planning of the State Education Building, which was completed in 1913. In the autumn of that year the State Museum began to move into its new quarters, the entire upper floor, with 60,000 square feet of space. One half of this is devoted to geology and paleontology, an expansion that brought about an increase in the staff and a modernization of the grand collections. The opening of the building took place on December 29, 1916, before the assembled geologists, who were addressed by Theodore Roosevelt. New York now has the best state museum in America, with the finest array of highly significant Paleozoic fossils. From the paleontological side, in fact, it possesses one of the world's most valuable collections, containing upward of 7,000 type specimens, and constituting a mecca to which all students of the older Paleozoic come for inspiration and interpretation. Here also are to be seen most artistic and lifelike restorations of Ordovician, Silurian and Devonian marine assemblages, and this type of teaching had its culmination last February, when Clarke placed before the public a restoration of the Gilboa Devonian forest, a living picture of the first flora to clothe Mother Earth. The New York State Museum is beyond question Clarke's greatest monument.

The philosophy of Clarke's paleontologic studies is to be found mainly in three of his papers, namely, his address to the Paleontological Society as its first president (1911); "The philosophy of geology and the order of the state," being the presidential address to the Geological Society in 1916; and "Organic dependence and disease," published in 1921. His conception of what the life of the past should mean to the living human world may be summed up as follows:

"Paleontology is . . . the most far-reaching of all the sciences. In it lies the root of all truth, out of it must come the solution of the complex enigmas of human society." The great significance of evolving life as seen throughout the geologic ages came to Clarke from his studies of the earliest phases of the parasitic or dependent conditions of life—a study of mutual organic associations that led to commensalism, sessility and finally to parasitism. These modes of life involve "the essential abandonment of normal direct, upright living and the benefactors thereby are types of life which Nature has cast out and aside as hopeless. . . . Individual and locomotive independence, it would seem, has been the major function and prime determining factor in the progress of life. . . . All progress in life, as reckoned in terms of man, has come through independence and through those lines of animal life in which independence has been maintained at any cost. . . . Rescue of dependents is therefore not a part of the scheme of Nature, except through the exercise of intelligence."

On the other hand, the communal life of the social insects shows that "socialism and communism have been tried out and found wanting, and Nature holds conspicuously before the eye of the State the warning that they have nothing either for the growth of the spirit or the progress of the intellect."

"Nature makes for the individual," and this truth "is registered on the tablets of the earth. . . . Over and over again the dominant race has started on its career as an insignificant minority struggling for its existence against an overburden of mechanical and vital obstacles, armed only with specific virtues which have little by little fought their way into the foreground, and by so doing consummated their upward purpose. . . . The majority is purely numerical, while wisdom and truth may rest with the minority. . . . The voice of the people is not the voice of God."

The paleontologist, looking at the record of life on the earth, says to the state: "Be intelligently guided in the treatment of hereditary community parasites, defectives, congenital or confirmed misdemeanants, whatever the form of degeneration may be, by recognition of the presumption that in so far as they can not be physiologically corrected, they are abandoned types in which there lies little hope of repair."

Of "honors which beautify and crown success," Clarke had many: was elected to membership in numerous scientific and historical societies in this country, Canada, England, Germany, France and Russia; made an Immortal in the National Academy of Sciences in 1909; elected vice-president of the Geological Society of America in the same year, and its president in 1916; made first president of the Paleontological Society in 1909; awarded the Prix de Léonide Spindiaroff by the International Geological Congress in 1910 for his geologic work in Gaspé; awarded a gold medal by the Permanent Wild Life Protection Fund (1920), the Hayden Gold medal of the Philadelphia Academy of Natural Sciences (1908), and the Thompson Gold Medal of the National Academy of Sciences (1925); received an honorary Ph.D. degree from the University of Marburg in 1898, that of Sc.D. from Colgate in 1909, Chicago in 1916 and Princeton in 1919, and that of LL.D. from

Amherst in 1902 and from Johns Hopkins in 1915. According to letters from Professor Barrois, of the University of Lille, a further honor was soon to have been his through election to fellowship in the French Academy.

A study of John M. Clarke's works shows clearly that he was one of the greatest paleontologists of his time and one of the geniuses of science, "standing on the mountain-top and catching the first rays of the rising sun," pregnant with new views of nature. But an intimate knowledge of his life also reveals that his path to eminence was hewn out with much labor among his beloved fossils, taxing to the full the many-sided equipment that was his from home, college and environment.

CHARLES SCHUCHERT,
RUDOLF RUEDEMANN

SOME MATHEMATICAL ASPECTS OF COSMOLOGY

(*Continued from page 99*)

There are many more postulates that are worthy of discussion, but let us suppose that they have been read by title, and that our system of postulates is complete. Everything else that happens in our cosmology must be in harmony with them, for they are esthetic propositions and are not to be profaned with evidence. Evidence and experience are dealt with by *hypotheses,* which include all those statements which we usually call the laws of nature. Perhaps the most fundamental and the best verified of all hypotheses is Newton's law of gravitation, and yet the Neumann-Seeliger proposition, which we have already mentioned, shows that our mathematical formulation of it can not be rigorously true, since it conflicts with our system of postulates. The statement that the effects of a displacement of a body are perceived at distances, however remote, instantaneously is quite likely to be in conflict with any serious system of postulates. Newton's formulation is delightfully simple, and its predictions are almost perfect, but I should very much prefer to think that at distances sufficiently great the attraction of any body whatever is rigorously zero, rather than merely very small. However that may be, we must not push Newton's law "to the limit"; nor, indeed, are we justified by evidence in pushing any physical law "to the limit."

Similarly, the inverse square law enables us to compute in an entirely satisfactory manner the attraction of an electrically charged surface for an oppositely charged particle, provided the particle is not in the surface. If the particle is in the surface the situation is mathematically indeterminate. We escape this evil consequence by a hypothesis of fine structure, so that what is a mathematical surface for some purposes is not at all a mathematical surface for others. Again we must not push the law of attraction to the limit. Perhaps a theory of fine structure could be made to account for the complete disappearance of gravitation at distances sufficiently great. However fine the structure may be, eventually it becomes too coarse for gravitation to act.

A second conflict with our postulates is found in the law of radiation, which, again, is an inverse square law. We have already seen that if this law were rigorously true the entire sky would be as bright and as hot as the disk of the sun. The evidence is squarely against it. Relative to such a situation the sky is very dark and cold, and we must admit that the law is not rigorously formulated. But radiation is energy, and energy can not disappear into empty nothingness. It was this difficulty which led me some ten years ago to make the hypothesis[38] that radiant energy can and does disappear into the fine structure of space, and that sooner or later this energy reappears as the internal energy of an atom; the birth of an atom with its strange property of mass being a strictly astronomical affair. Indeed, with an infinite sequence of physical units, no smallest one and no largest one, each an organized system of smaller units, and none eternal, one can hardly escape the hypothesis that energy runs up and down the entire sequence, and that on the whole as much energy is ascending as is descending.

The rate at which radiant energy is being absorbed in space, and consequently the rate at which atoms are being formed, must be very small relative to the standards of a physical laboratory. Trigonometric parallaxes show that there are only six or seven thousand stars within 100 light years of the sun, while estimates for the entire galaxy run from one to two billion. The distance of most of the stars must be great as compared with 100 light years. Assuming the rate of loss of energy to be proportional to the distance travelled, we find that the radiant energy decreases according to an exponential law, and since the reliable distances are certainly very great the rate of loss must, with equal certainty, be very low. But if this loss is only one per cent. in one hundred light years, the Andromeda nebula is at a distance of less than 50,000 light years instead of 1,000,000 light years as at present estimated.

There is nothing particularly strange about the idea that atoms, or electrons, are formed from

[38] *Astrophysical Journal,* July, 1918. See, also, *Scientia,* January-February, 1923.

smaller units by the addition of a suitable quantum of radiant energy. We all agree that the periodically recurring beauties of the springtime are due to a similar process and that the organic molecules, with their host of marvelous properties, are somehow built up by radiant energy from inorganic molecules. The properties of the organic molecules are not less marvelous than the property of mass, but the rate at which these systems come and go enables us to observe many cycles, while the lives of the atoms are in general very long. Possibly a scientifically inclined mosquito might wonder why the process of vegetable growth has not exhausted the carbon dioxide of the atmosphere long ago.

The hypothesis that atoms are generated by the radiant energy of space does much more than merely account for the blackness of the night sky, which suggested it. It accounts for the existence of that nebulosity with which cosmogonists have always started, and which is so striking a feature of the astronomer's photographs. Even in the apparently dense Orion Nebula it is extremely attenuated, the wonder being that it is visible at all. There is nothing, however, to suggest that these nebulae contract into suns, as was taught during the nineteenth century, and is still largely believed to-day. The twenty million years assigned for the life history of the sun by the contraction theory of Helmholtz is absurdly small even for the requirements of the geologists, perhaps not over one or two per cent. of the required amount; and it vanishes almost completely in comparison with the vast stretches of time which are fundamental in the dynamics of the galaxy.

For example, the close approach of two stars is a primary event in the evolution of a cluster of stars, corresponding to collisions in the kinetic theory of gases. The expectancy of any one star for an approach as close as the earth to the sun, that is, one astronomical unit, is of the order of a million billion (10^{15}) years. If we call such an interval of time an *eon*, then the *eon* is a convenient unit of time in describing the history of the galaxy. The statistical studies of Charlier and of Jeans have shown that the galaxy has made observable progress towards the steady state which we can regard as the state of maturity.[39] The phenomena of star clusters and star clouds, groups of stars possessing common motion, shows that the galaxy is still a youthful aggregate of stars. Quite likely its present age is to be measured by hundreds of eons, and its state of maturity is still distant by thousands of eons, if it ever arrives. Our information is quite inadequate to probe the possibilities of such vast stretches of time.

[39] See Jean's "Problems of Cosmogony," p. 236.

It should be said, however, that smaller aggregates, the globular star clusters, seem to have arrived at the steady state.

Such considerations force the problem of the source of stellar energies vividly upon our attention. But if the atoms are systems containing energy, as we have supposed, then here is a source that, at least, is worthy of investigation. Possibly in the sun these energies are released just as the stored radiant energy of a cord of wood is set free in a fire. The mechanism of that release is to be found in the intense gravitational stresses which exist in the interior of a star. The earth is a small body astronomically, but the pressure at its center is 22,000 tons per square inch, or a hundred times the greatest pressure attainable in our physical laboratories. For bodies of the same density the pressure varies as the square of the radius. For bodies of the same material in the same physical state, increase of pressure results in increased density, and therefore the pressure increases faster than the square of the radius. A body similar to the earth, but of twice its radius, has a central pressure of 100,000 tons per square inch; double it again, and the pressure rises to 500,000 tons, and we have only reached the size of Uranus and Neptune which are still small bodies astronomically.

If we appeal to the postulate that *no organized system can withstand an unlimited amount of violence,* it is evident that there is an upper limit to the mass of a solid body. The atoms break down and give up their energy. Imagine the earth to be growing by the addition of meteoric material and nebulosity picked up from space, and imagine this material similar to that which the earth already has. The mass begins to get hot. Permanent gases escape from the interior and enlarge the atmosphere. Eventually, even the surface becomes too hot, and the ocean rises in a cloud of steam. The more volatile substances pass over into the atmosphere, and there is a gradual change from the solid state to a gaseous state accompanied by a marked decline in the mean density. The gaseous state having been reached, a further increase in mass results at first in an increase in density due to compression, just as it does in the solid state. Increase in density can not go on indefinitely in the gaseous state, however, any more than it can in the solid state. The expansive effect of the heat which is liberated by the increasing mass gradually overtakes the compressive effects of gravitation, and there is a second maximum in the density mass curve. For still greater masses the density continues ever afterwards to decline, owing to the excessive generation of heat; the curve becoming asymptotic to the axis of zero density. The mass begins

to glow with a dull red heat, becoming brighter as the mass increases until the entire mass is white hot.

These are consequences which follow from the hypothesis that the atoms are destroyed by sufficiently great gravitational stresses. How does it fit the evidence? Experiment, of course, is out of the question, but we can examine at least some of the astronomical bodies. Commencing with the satellites and planets of our own system, we find that all bodies smaller than the earth are solid and that on the whole the density rises as the mass increases. The next bodies more massive than the earth are Uranus and Neptune, 14 and 16 times the mass of the earth, respectively. Their density is approximately the same, and about one fourth of the density of the earth. The maximum solid body is apparently slightly more massive than the earth, and Uranus and Neptune are in the transitional stage from solids to gases. Passing next to Saturn, which is 95 times as massive as the earth, we find a density only .6 that of water. Saturn is near the beginning of the dark gaseous state. Jupiter is more than three times as massive as Saturn and its density is nearly twice as great. Jupiter is the largest dark body in our planetary system. There are not enough bodies in our system to locate exactly the second density maximum. There is also a value at which the mass becomes red hot, and is therefore a dull, feeble star. This point is perhaps 100 times the mass of Jupiter, as there is no star whose mass is known to be less than one tenth of the mass of the sun.

One of the fundamental modern contributions to our knowledge of the stars was made by Russell in 1911 in establishing, by statistical methods, the existence of the dwarf and giant series, a classification due originally to Hertzsprung, on the basis of absolute luminosities. Stars of all spectral classes occur in both series. The dull-red, dwarf stars were found to be dense, and to average one half the mass of the sun. As the stars of the dwarf series brightened and became yellow and then white, the average mass increased and the density decreased until for the very white stars the mass was five and one half times the mass of the sun. Passing then to the giant series, as the star's colors passed from the white to the yellow to the red, the mass still further increased to about fifteen times the mass of the sun, while the luminosity increased but slightly, and the density fell to very low figures.

Russell's interpretation[40] of these facts was very different from that which I am suggesting, but it can not be doubted that these facts are precisely those which I should anticipate. In the case of the giant red stars with a diameter of two or three hundred millions of miles, the furious radiation near the center must be blue white, but this type of radiation can not penetrate its enormous atmospheric envelope, which is of course relatively much cooler; and the star is red, partially for the same reason that the sunset is red, partially because the radiations from the relatively cool atmosphere also are red.

The energy which a star can draw from its own mass is limited, just as the energy which it can draw from the contraction theory is limited. But as a star moves through space it picks up atoms and molecules or stray meteors or a comet and adds to its mass. Occasionally it enters a distinctly nebulous region, and its mass grows with relative rapidity. We have only to suppose that, on the whole, it picks up as much mass as it loses by radiation to provide for an indefinite duration to its period of luminescence. Its brightness will fluctuate with its mass. At times it will decline to the point of extinction; at other times it will pass over into the giant stage.

Let us see what we might anticipate for the future of our solar system during the next few eons. The mass of the sun will fluctuate, but the planets can scarcely do anything but grow. When the sun declines in mass the planets will recede, the distances of the planets being inversely proportional to the sun's mass. Under these circumstances, the planets become more sensitive to the perturbations of passing stars, and there is greater possibility of the eccentricities being increased. When the mass of the sun is growing, however, as it will when in a densely nebulous region, the planets are growing too. Assuming that the ratios of the masses are maintained, the planets draw closer to the sun, the distances being inversely proportional to the cube of the masses,[41] and the eccentricities tending towards zero. If the material is gathered in at random from all directions the planets will grow without substantially altering their distances, or eccentricities. In this manner we see the planets gradually growing towards starhood. Let us suppose that Jupiter has grown to be a dwarf red star, while the sun has just held its own. The distance between them will be reduced, but how much will depend upon the circumstances of growth. Let us suppose it is one half their present distance. Suppose finally they enter a nebulous region, and their masses slowly grow to four times their initial masses. Their distances will be reduced to four million miles and their period to about a day and a half. Jupiter and the sun will form a typical spectroscopic binary star. The earth and the inferior planets will have been

[40] "The Observatory," 1913, 1914.

[41] See MacMillan, "The growth of the solar system," *American Mathematical Monthly*, October, 1919.

swallowed up by the sun. The fate of Saturn, Uranus and Neptune is not clear, but the probabilities seem to favor their extinction also. If the masses of Jupiter and the sun were increased to five times the initial mass, their distances would be reduced to two million miles and their period to about twelve hours. They would be inside of Roche's limit and there would be some kind of a cataclysm, possibly of a type that would account for the existence of cepheid variables. If a star were once started into pulsations, which is Moulton's hypothesis for cepheids,[42] there would be an excessive release of energy at the time of compression, and this extra energy would keep the pulsations going.

We see then that the matured state of a planetary system is a binary or perhaps even under favorable circumstances a multiple star. From the developments of the planetesimal hypothesis, it is to be expected that planetary systems are normal to all stars; that 40 per cent. of the stars, which is the percentage estimated to be binaries, should have matured families is not surprising. If four eons is the expectancy of any one star for the generation of a family, then four eons should measure the normal existence of a planetary system, including the binary star stage, though of course there would be wide variations from the mean.

It is evident, too, that if the rate of radiation of a star is proportional to some power of the mass higher than the first power, which is the case, according to Eddington's and Jeans's figures,[43] then the masses of a binary star tend towards equality, which, as we have already observed, is strikingly the case. It should be remarked, however, that if the disparity of masses is too great, say, ten to one, the chances of discovery that a star is binary is much diminished. If a binary star belongs to the dwarf series we should expect the less massive star to be redder, but if the star belongs to the giant class we should expect the more massive star to be the redder. Shajn[44] has recently stated that this is the case.

Let us imagine that a large volume of extra galactic space has become nebulous in the course of eons by the passage of radiant energy through it. It is penetrated by wandering stars which we recognize within the galaxy as the runaway stars, that is to say, stars within the galaxy, but, on account of their high velocities, not permanent members of it. As the star gathers in the nebulosity and adds to its own mass, its velocity relative to the nebula is reduced, so that it is unable to escape the gravitative control of the nebula. In the course of time many stars will be caught in the same way, and we have the beginnings of a star cloud. Many star clouds in the same neighborhood, if their total moment of momentum was not zero, would begin to move about one another and form such a system as our own galaxy. Or, if the star cloud was single and isolated, it would develop into a globular star cluster, of which there are some eighty examples. As Shapley's researches indicate, these clusters are very remote.

The mode of disintegration of such systems also is clear. Occasionally two stars will approach in such a way that one of the pair is given a velocity sufficiently great for it to escape from the system altogether. Even though such events are extremely rare, a few stars must be lost in this way; but a general disintegration of the system is due to an exhaustion of nebulous material. In a sufficiently prolonged period of famine the masses of the stars decline, the cluster expands, and one by one the stars escape from the group control and resume their primitive state of solitude. So far as I can see, a star can lose its identity only by colliding and uniting with another star, but a star cluster, which includes even the galaxy, loses its identity by a process which is similar to evaporation.

Such, in a hasty way, is the astronomical evidence which justifies a consideration of the hypothesis that the energies of the stars are derived from the consumption of their own masses and that new atoms are generated in the depths of space through the agency of radiant energy. Let us turn now to the domain of physics and see what justification we can find from modern physical concepts. Every one knows that the modern physicist regards all atoms as being built up of positive and negative electrons, which are very small as compared with an atom. Each positive electron carries a positive charge of electricity, and each negative electron carries a negative charge of electricity. These charges are all sensibly equal numerically. Unlike charges attract each other according to the inverse square law, and similar charges repel each other. Matter is electrically neutral, because the atoms are composed of equal numbers of positive and negative electrons. The hydrogen atom, which is the simplest atom, is a binary star, while other atoms are multiple stars of more or less complexity; and the physicists are busy working out the electronic orbits. As for their concepts of the nature of mass, I can not do better than the following quotation from Millikan:[45]

> But though we have thus justified the statement that electricity is material, have we any evidence as yet that all matter is electrical—that is, that all inertia is of the same origin as that of an electrical charge? The answer is that we have *evidence* but as yet no *proof*. The theory

[42] *Astrophysical Journal*, May, 1909.

[43] Monthly Notices, January, 1925, p. 209.

[44] Monthly Notices, January, 1925, p. 248.

[45] R. A. Millikan, "The Electron" (1917), p. 183.

that this is the case is still a speculation, but one which rests upon very significant facts. These facts are as follows:

If a pith ball is spherical and of radius a, then the mass m due to a charge E spread uniformly over its surface is given, as is shown in appendix D, by

$$m = 2/3\ E^2/a \quad . \quad . \quad . \quad . \quad (32).$$

The point of especial interest in this result is that the mass is inversely proportional to the radius, so that the smaller the sphere upon which we can condense a given charge E, the larger the mass of that charge. If then we had many means of measuring the minute increase in mass of a pith ball when we charge it electrically with a known quantity of electricity, we could compute from equation (32) the size of this pith ball, even if we could not see it or measure it in any other way. This is much the position in which we find ourselves with respect to the negative electron. We can measure its mass, and it is found to be accurately 1/1,845 of that of the hydrogen atom. We have measured accurately its charge and hence can compute the radius a of the equivalent sphere, that is, the sphere over which e would have to be uniformly distributed to have the observed mass, provided we assume that the observed mass of the electron is all due to its charge.

The justification for such an assumption is of two kinds. First, since we have found that electrons are constituents of all atoms and that mass is a property of an electrical charge, it is of course in the interests of simplicity to assume that all the mass of an atom is due to its contained electrical charges, rather than that there are two wholly different kinds of mass, one of electrical origin and the other of some other sort of an origin. Secondly, if the mass of a negative electron is all of electrical origin, then we can show from electro-magnetic theory that this mass ought to be independent of the speed with which the electron may chance to be moving unless that speed approaches close to the speed of light. But from one tenth the speed of high up to that speed the mass ought to vary with speed in a definitely predictable way.

Now it is a piece of rare good fortune for the testing of this theory that radium actually does eject negative electrons with speeds which can be accurately measured up to ninety-eight hundredths of that light. *It is further one of the capital discoveries of the twentieth century that within these limits the observed rate of variation of the mass of the negative electron with speed agrees accurately with the rate of variation computed on the assumption that this mass is all of electrical origin.* This leaves no room for a mass of any other kind to be associated with the free negative electron. Such is the experimental argument for the electrical origin of mass. . . .

In the case of the positive electron there is no direct experimental justification for the assumption that the mass is also wholly of electrical origin, for we can not impart to the positive electrons speeds which approach the speed of light, nor have we as yet found in nature any of them which are endowed with speeds greater than about one tenth that of light. But in view of the experimental results obtained with the negative electron, the carrying over of the same assumption to the positive electron is at least natural. Further if this step be taken, it is clear from equation (32), since m for the positive is nearly two thousand times larger than m for the negative, that a for the positive can be only 1/2,000 of what it is for the negative. In other words, the size of the positive electron would be to the size of the negative as a sphere having a two mile radius would be to the size of the earth. From the standpoint then of the electromagnetic theory of the origin of mass, the dimensions of the negative and positive constituents of atoms in comparison with the dimensions of the atoms themselves are like the dimensions of the planets and asteroids in comparison with the size of the solar system. All these computations, whatever their value, are rendered possible by the fact that e is now known.

Now we know from methods which have nothing to do with the electromagnetic theory of the origin of mass that the excessive minuteness predicted by that theory for both the positive and negative constituents of atoms is in fact correct, though we have no evidence as to whether the foregoing ratio is right.

Without concerning ourselves as to the ultimate nature of electricity we can write down the mutual electrostatic potential energy of a positive and a negative electron, *viz.*, $V = \frac{e^2}{r}$, where e is the charge of an electron,[46] 4.774×10^{-10}, and r is the distance between them. In the atom the electrons are in orbital motion and they do not fall together for the same reason that the planets do not fall into the sun. In the interior of a star, however, the integrity of an atom can not be preserved on account of the violence of the gravitational stresses. There must be a vast quantity of free electrons moving at extraordinary speeds. If a positive and a negative electron collide and unite, so that their electrical fields are exactly superposed, the two opposite charges of electricity neutralize each other, and the property of mass disappears for the combined unit. The energy released could be computed if we knew the value of r at which the energy changes from the potential to the radiant form. If it is assumed to be the radius of the negative electron, 2×10^{-13} as given by Millikan, it is found that one gram of matter (equal to 6.06×10^{23} hydrogen atoms) is equivalent to 1.2×10^{10} calories; while if we take the radius of the positive electron it is 2.4×10^{13} calories.[47]

[46] Millikan, "The Electron," p. 119.

[47] The idea that the energies of the stars and of the sun are derived from the consumption of their own masses was suggested to me some ten years ago by the blackness of the night skies. It was frequently discussed with my colleagues and my classes and was published in the *Astrophysical Journal* in July, 1918. The idea that the

The theory of relativity has an advantage here in that it gives a perfectly definite relationship between mass and energy.[48] According to this theory one gram of matter is equivalent to 9×10^{20} ergs, or 2.17×10^{13} calories; and this gives a value of the radius at which the energy is transformed about 10 per cent. larger than Millikan's value for the positive electron. As the sun radiates approximately 1.5 calories per year per gram of its mass, the sun's present mass would supply its radiation for about fifteen thousand billion (15×10^{12}) years, or 1/70 of an eon, if one adopts the larger figures, as I am inclined to do. On this basis the sun radiates 1.2×10^{20} grams per year. Taking the sun's effective radius for sweeping up the materials of space at 14,000,000 miles,[49] and its present speed of about twelve miles per second, the mean density of space necessary to maintain the sun's mass is of the order of 10^{-19}, a density perhaps not impossible. This would be the density if one cubic foot of normal atmospheric air were expanded so as to fill a cube the edge of which was thirty miles.

I do not insist upon these figures, however, as they depend upon hypotheses which can not be verified directly. It is overly optimistic, perhaps, for us to expect any direct experimental evidence which will guide us with certainty over those vast stretches of time for which the eon is a convenient unit, and which certainly are necessary in a consideration of the dynamics of the galaxy and of super-galaxies. The main point is that modern physics furnishes a model already made in the theory of electrons, for our hypothesis, which was based originally upon astronomical evidence, that the energies of the stars are derived from the consumption of their own masses and that the atoms are generated by the radiant energy in what we ordinarily call empty space, although, according to our postulates, space is nowhere empty; furthermore, the energy which is furnished by this model is sufficiently great to meet the immediate requirements of astronomy. I do not think that it tells the whole story, nor do I think that the whole story will ever be told, however long the human race may live or however wise it may become; but it does relieve us of our pressing embarrassments.

It permits us to see that in our physical laboratories and in our observations of nature we are merely watching the courses of the atoms as they are tossed about by the various forces which they encounter on their journey from their birthplace in the depths of space to the place of their extinction in the interior of some star. We are studying only one aspect of the transformations of energy, and hence we derive our second law of thermodynamics. The water which we see is all on its way down the hill. We have ignored the existence of the radiant energy of space, and the question as to what becomes of it. It is inaccessible and out of sight. It is only with the imagination that we can follow it, just as it is only with the imagination that we can follow the water as it changes to vapor at the surface of the sea and condenses back to water again high up among the clouds. We should expect some such doctrine as that of entropy in the world of matter, but it is not a valid doctrine for all possible transformations of energy. According to postulate 13 the universe does not tend constantly in any one direction.

There is a corollary to such a universe as we have postulated that has a strong human appeal. Life is not a phenomenon peculiar to the earth. It exists upon the earth because the conditions upon the earth have been favorable for a sufficiently long period of time. In the past million years or so, it has developed a certain small degree of intelligence, and the race of man is beginning to pry into the secrets of nature with a real curiosity. Elsewhere in an infinite universe there are other suitable abodes, infinitely many, with races of living beings upon them. Some of these races are young, some of them are vastly older than ours, more highly developed, much wiser. Such races existed before the earth was formed or even before the sun started upon its career as a star; after the earth and even after the sun has passed out of existence, other races of living beings elsewhere will

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property of mass was lost by the exact superposition of the electrical fields of the electrons was suggested to me early in 1919 by Millikan's book, "The Electron," and this idea fitted perfectly into the gap which I had left in my previous paper. It was stated in a lecture before the Sigma Xi on March 11, 1920, and published in SCIENCE July 23, 1920.

I have learned recently that in a letter to *Nature*, Vol. 99, p. 445, Aug. 2, 1917, Eddington mentioned as a conceivable idea "a gradual annihilation of matter by positive and negative electrons occasionally neutralizing one another" and ascribed the idea to Jeans. Jeans did not regard the idea as worthy of discussion in his book, "Problems of Cosmogony," and definitely tied his cosmology to the contraction theory of Helmholtz."

[48] A. Einstein, "Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?" Annalen der Physik 18, 639 (1905). In this paper Einstein states that from the point of view of relativity the mass of the sun is diminishing on account of its radiation, and he gives the numerical relationship mentioned in the text. He does not suggest, however, that the number of its atoms is diminished thereby, nor that its gravitational field is weakened.

[49] See MacMillan, "The Growth of the Solar System," *Am. Math. Monthly*, October, 1919, p. 328.

be repeating with infinite variations the experiences which we are having upon the earth at the present time.

Atoms, living beings, stars and galaxies are permanent forms in the universe. It is the individuals only that come and go.

WILLIAM D. MACMILLAN
THE UNIVERSITY OF CHICAGO

THE CENTENARY OF WILHELM HOFMEISTER

DOUBTLESS many can recall certain books which have greatly influenced their lives, and in my own case one stands out especially—a translation of Hofmeister's epoch-making treatise on the comparative morphology of the archegoniate plants. This book, studied while an undergraduate at the University of Michigan, was undoubtedly the most important factor in determining the trend of my botanical investigations for many years.

It was, therefore, particularly interesting for me to find myself a few years later a student in the botanical institute at Tübingen, where Hofmeister spent the last years of his life.

This picturesque old Suabian town, not far from the Black Forest, lies in the beautiful valley of the Neckar, surrounded by an extremely attractive country. Tübingen will always be famous in botanical annals as the domicile of a line of great botanists, among whom three may be especially mentioned—Mohl, Hofmeister and Pfeffer—surely a sufficiently notable trio for one small university.

Mohl, one of the greatest botanists of his time, founded the botanical institute at Tübingen, in its earlier days the best equipped in Germany.

During my sojourn for the summer semester of 1887, Pfeffer was director, but in the autumn of that year he removed to Leipzig, where his brilliant record is familiar to all botanists, and where many American students studied under his direction.

These memories of Tübingen were recalled through a recent address[1] by one of Hofmeister's most distinguished students, Professor Goebel of Munich. This was delivered at Tübingen, at the celebration held on May 18, 1924, the hundredth anniversary of Hofmeister's birth.

In these days, when the study of comparative morphology is looked at more or less askance by many of our younger botanists, the immense significance of Hofmeister's early work is scarcely understood. These remarkable investigations, necessarily lacking some of the precision made possible by modern technical methods, nevertheless form the solid foundation upon which has been raised the great edifice of comparative morphology, and there is no question that Hofmeister's work will remain as probably the most brilliant contribution ever made to this fundamental department of botany.

Hofmeister's activity began in the period which Goebel has called the "renaissance of botany," when botanists began to break away from the Linnean tradition which for the first third of the nineteenth century was still dominant, and made taxonomy the all-important subject of botanical activity. The brilliant beginnings of anatomy and physiology, made in the seventeenth and eighteenth centuries, had almost sunk into oblivion.

Among the great names of this renaissance is Hugo von Mohl, whose name will always be associated with the study of protoplasm, to which he gave the name still in use. As we have already stated, Mohl was the first director of the Tübingen botanical institute, and was succeeded by Hofmeister.

Hofmeister's first paper was published when he was twenty-three. *A propos* of this Goebel writes:[2] "This was especially remarkable as he was entirely self-taught. It is true that at this time there were no botanical institutes where one could receive instruction in botanical investigation. The technical methods were not so developed and mechanical as is the case to-day, when often the technique of a botanical investigation has a greater specific weight than its 'Gedankennihalt'!"

In 1851, when he was twenty-seven years old, he published his remarkable studies on the structure and development of the archegoniate plants—mosses and ferns; and somewhat later his investigations were extended to include the seed-bearing plants as well. It is these "Vergleichende Untersuchungen" which are Hofmeister's greatest contribution to science and which rank with the most important that have ever been made.

These investigations covered a wide range of forms, and demonstrated beyond question the essential similarity between the archegoniates and the lower seed-plants, and effectively broke down the supposed barrier between "Cryptogams" and "Phanerogams." They showed the essential likeness in the life-histories of all these plants, the regular alternation of sexual and non-sexual generations; and eight years before the appearance of the "Origin of Species," gave a concrete demonstration of the derivation of the higher types of plants from lower ones.

The importance of these investigations as bearing

[1] Goebel, K. Wilhelm Hofmeister. Tübinger Naturwissenschaftliche Abhandlungen. 8. Heft. Tübingen, 1924.

[2] *Loc. cit.*, p. 2.

upon the theory of evolution was recognized in England, and in 1862 a translation was published by the Ray Society.[3]

Hofmeister was born in Leipzig, where he passed through the Realschule, but did not attend the university. He took up a business career as a music dealer. How he accomplished the extraordinary output of scientific work, culminating when he was only twenty-seven in the famous "Vergleichende Untersuchungen" which inaugurated a new era in plant morphology, is a mystery. It would seem that his music business could hardly have been a very flourishing one. It would do no harm if some of our present-day investigators who are wont to complain of lack of time for research could be reminded of the conditions under which Hofmeister's most important work was done.

He was soon recognized as one of the outstanding scientific figures of his time, and in spite of the fact that he had never attended a university, he was later given the doctorate, and in 1863 was appointed to a professorship at Heidelberg. Nine years later he was called to Tübingen as Mohl's successor.

Owing to failing health, he retired from active work some time before his death, which took place at Lindenau near Leipzig, January 12, 1877.

Whatever phase of botany may happen to be the fashion as each new crop of workers comes up, and however often the point of view may change, it is safe to predict that Hofmeister will remain in the front rank of the great masters of botany.

DOUGLAS HOUGHTON CAMPBELL
STANFORD UNIVERSITY

[3] "On the Germination, Development and Fructification of the Higher Cryptogamia, and on the Fructification of the Coniferae." Translated by Frederick Currey, M.A., F.R.S.

SCIENTIFIC EVENTS

THE BRITISH ASSOCIATION

DETAILS of the local arrangements for the Southampton meeting of the British Association for the Advancement of Science, which meets from August 26 to September 2, under the presidency of Sir Horace Lamb, are given in *Nature*.

The reception room will be the King Edward VI Grammar School, which is conveniently and centrally situated, facing the open space called the Marlands, on one side of which is the public stance for charabancs, while close behind it is the West Station on the main Southern Railway line from Waterloo to Weymouth, at which most of the visitors to the meeting will alight from their trains. For the convenience of the members it has been arranged with the railway authorities for a special train to be run from Waterloo on the day before the opening of the meeting (Tuesday, August 25). Within easy distance of the Grammar School are to be found the shops and restaurants of Above Bar Street, and an agreement has been reached with a firm of local caterers to take for the week of the visit the Coliseum, a hall capable of seating 1,600, and run it as a restaurant at which lunches and teas may be had.

Garden parties have been offered by Lord and Lady Swaythling at Townhill Park; Lord and Lady St. Cyres at Walhampton, near Lymington, and Mr. W. Collins at Westend; while the Cunard and White Star Companies have invited as many members as may care to go to see over one of their ships.

Southampton is remarkable for its fine open spaces, which stretch from the lower part of the town almost without break to the Southampton Common, the latter covering an area of more than 360 acres of virgin land. Its immediate environs include many places of great natural beauty. General excursions are being arranged to visit old Southampton, the Docks, New Forest, Stonehenge and other places of interest in the neighborhood. The full list of excursions, including sectional ones and visits to works, will be given later in detail. While tickets for the general excursions will be obtainable at a counter in the reception room, those for all the sectional excursions may be had from the local sectional secretaries at the various rendezvous of the sections during the week of the visit. The committee of the Royal Yacht Club has very kindly extended hospitality of honorary membership to the visiting members of the British Association.

ANTI-VIVISECTION

WE are permitted to publish the following correspondence between Dr. David Starr Jordan and Mr. Luther Burbank:

STANFORD UNIVERSITY P. O.
CALIFORNIA
June 1, 1925.

Mr. Luther Burbank
Santa Rosa
California.

My dear Burbank:

Will you pardon one of your oldest friends to express sincere regret over your endorsement of the work of an "Anti-vivisectionist Society?"

To my mind, and I have good reason to know it, this movement is based on the same kind of ignorance and prejudice that animates the much less mischievous anti-evolutionist organizations. The progress of sanitation, associated with that of medicine, has been along the very firing line of science for the last fifty years, ever since the discovery of bacteria and their relation to infectious

disease. The result of research on diet and causes of disorder has been to lengthen the life of the average civilized man for by fifteen to twenty years. Till these days of experiment, physicians were able to treat symptoms mainly, for the solid basis of science had not been reached.

An example of the method of science is that by which Dr. Walter Reed and his associates have controlled yellow fever. The noble work of my old friend, Professor Ricketts, in making clear the nature of "mountain fever" in Montana, and of typhus in Mexico (in which he fell himself a martyr), will also illustrate.

Intensive study of another type of disorder, sugar poisoning, gave us insulin, a drug which has already saved thousands of lives condemned to death by diabetes.

Most such studies can only be made by tests on certain animals, rabbits, guinea pigs, rats, goats, dogs and sometimes monkeys or horses. Literal "vivisection" (cutting them up alive) is a rare thing, not done without anaesthetics. Certainly it has never been wantonly practiced by any sane man engaged in real research. There are two or three cases on record where outrageous acts have been committed, mostly so far as I know in France. Napoleon gave the cue: when he said that "a great soldier like me does not care a tinker's dam for the lives of a million men." But the greatest of Frenchmen, Pasteur, was guided solely by the spirit of helpfulness.

There may have been some cases of some tyro teacher cutting up a live animal for class illustration. But I have not heard of a case for forty years, and it has nothing to do with medical research as practiced in legitimate colleges or in actual centers of research like the Rockefeller Institute.

"Anti-vivisectionist" publications, so far as I have seen them, show certain traits:

1. Sheer ignorance of discoveries of the last half century, notably as to bacteria and protozoa.
2. Quotations from "eminent physicians" without names or dates.
3. Careless or conscienceless use of quotations from men of science.
4. Alliance with advocates of "freedom in medicine," which would double the horde of impostors who prey on the ignorance of the public in regard to medicine and sanitation.
5. Encouragement of faith-healing cults, sincere enough, but capable of dealing only with the promotion of optimism, a method which in many cases may be of positive use in certain types of disorder, but tragic if adopted for setting a broken leg, in treating an infectious malady and the like.

You would not think it workable truth to ascribe your plant successes to your magical control over the fatty matter ("materia pinquis") of the earth by waving of sensitized wands, rather than to scientific operations of selection, hybridization and segregation. I know of people who have gone to Santa Rosa to "see the wizard wiz." always went for exactly the opposite purpose, to see how great useful results can be achieved by rigid use of all knowledge secured within the field of plant development.

With high appreciation of all your many services to clear thinking, as well as to horticulture, I am

Very sincerely yours,

(Signed) DAVID STARR JORDAN

SANTA ROSA, CALIFORNIA
June 2, 1925.

Dr. David Starr Jordan
Stanford University
California.

Dear Dr. Jordan:

I thank you most heartily for your very kind and very acceptable letter of June 1st, and you do state the truth in the case without doubt very accurately. I have been told by those who have participated that vivisection has been practiced on animals even in the High Schools by those who did not intend to take a medical course. And also I have had statements from parties at the State University who have told me that very evident cruelty has been practiced upon dumb animals.

I wrote that letter to the Anti-vivisection Society of California hastily and did not express myself as fully as I did to the New York Society which was more explicit in confining my remarks to the High Schools. I have never doubted the enormous value of the experiments that were carried on by real scientists anywhere or under any circumstances. I have seen the experiments of some of these scientists in the preparation of diphtheria vaccine, smallpox vaccine, typhoid fever vaccine and several other vaccines which have proved successful, these by scientists, and have never seen any unnecessary cruelty practiced upon any animals, either horses, guinea pigs, rabbits or other animals.

I hope this will make my standing plain to you and I do not question the facts stated in your letter which are all very true as far as I know. I am sure that we are both working for the best interests of humanity and if I have loaned my name to any parties who are working against science and humanity I wish to have my name taken from such organizations.

Faithfully yours,

(Signed) LUTHER BURBANK

INTERNATIONAL PHYSICAL UNION

DR. CHARLES E. ST. JOHN writes that at the general assembly of the International Physical Union on July 7, the significant action was taken, with no dissenting voice, that no international physical congress should be held until it is possible to make it international in fact.

After the rising of the general assembly of the Physics Union Professor Lorentz discussed the recent experiment of Michelson and Gale in connection with the original results found by Michelson. By use of the Stokes theory of the ether modified by a suggestion by Planck that the ether is compressible and subject to the action of gravity he thought the two

results could be reconciled. As to the findings of Miller he said that the preliminary results were in complete contradiction to the relativity theory as proposed by Einstein and if finally established they would mean the end of relativity in that form.

Professor Naguoka gave an account of his experiments on the transmutation of mercury into gold. He had used differences of potential of 200,000 and believed he had obtained particles of gold that were not in the mercury employed in his experiments as it had been 2–3 times distilled and subjected to careful chemical analysis. He expressed the desire that confirmation of his experiments be undertaken by other physicists.

SCIENTIFIC MEN AND THE DEFENSE OF MR. SCOPES

AN important part of the plans of the defense counsel in the case of State of Tennessee versus John T. Scopes, recently convicted of a violation of the Tennessee anti-evolution law, was the presentation of scientific evidence upholding the facts of evolution.

An attempt was made to obtain competent and well-known scientists in various branches to come to Dayton and testify in behalf of Mr. Scopes. Although the scientists were asked to serve without compensation other than their actual expenses, the response was gratifying. Due to the fact that the judge ruled that the scientists could not be placed upon the witness stand and that their testimony should only be submitted in written form for the consideration of the higher courts in the event of appeal, not all the scientists who would have been summoned in the event of direct testimony were asked to come to Dayton. Following is a list of those who actually came to Dayton: Dr. Charles H. Judd, University of Chicago; Professor William A. Kepner, University of Virginia; Dr. Jacob G. Lipman, director Agricultural Experiment Station, New Brunswick, N. J.; Dr. Fay-Cooper Cole, University of Chicago; Wilbur A. Nelson, state geologist, Nashville, Tenn.; Dr. Maynard M. Metcalf, Oberlin College and Johns Hopkins University; Dr. Winterton C. Curtis, University of Missouri; Dr. W. M. Goldsmith, Southwestern University, Winfield, Kans.; Dr. H. H. Newman, University of Chicago; Dr. Kirtley F. Mather, Harvard Geological Museum, Cambridge, Mass.; Dr. Frank Thone, Science Service; Watson Davis, Science Service.

Among those who had signified their willingness to come upon call of the defense counsel were: Dr. E. E. Reinke, Vanderbilt University, Nashville, Tenn.; Dr. Charles T. Oliver, McCormick Observatory, Charlottesville, Va.; Dr. Elmer Roberts, University of Illinois; Dr. Avery E. Lambert, University of Alabama School of Medicine; Dr. Ellsworth Faris, University of Chicago; Dr. R. T. Chamberlin, University of Chicago; Dr. David White, National Research Council; Dr. Anton J. Carlson, University of Chicago; Professor Charles A. Shull, University of Chicago; Dr. Homer N. Calver, American Public Health Association; Professor W. N. Rice, Wesleyan University, Middletown, Conn.; Professor Edward L. Rice, Ohio Wesleyan, Delaware, Ohio; Professor W. J. MacNeal, New York Post-Graduate Medical School; Professor Arthur McQ. Miller, University of Kentucky; Professor L. F. Rettger, Yale University; Dr. Shailer Mathews, University of Chicago.

Although the legal counsel for the defense, which consisted of Clarence Darrow, Dudley Field Malone, Arthur Garfield Hays, John R. Neal, were not technically trained in science, they won the admiration and confidence of the scientists who worked with them and they deserve the thanks of those working in science for their interest in protecting the right to teach the facts of biology. Dr. G. W. Rappleyea, manager of the Cumberland Iron and Coal Co., who instigated the test case against Mr. Scopes, also won the friendship and respect of the scientific witnesses and he deserves credit for having inaugurated and carried through the anti-evolution test case at Dayton.

WATSON DAVIS

SCIENCE SERVICE,
WASHINGTON, D. C.

SCIENTIFIC NOTES AND NEWS

PROFESSOR W. M. DAVIS, emeritus professor of geology at Harvard University, and Dr. G. Holm, of the Geological Survey of Sweden, have been elected foreign members of the Geological Society, London. Dr. T. W. Vaughan, director of the Scripps Institution; Professor P. Lemoine, professor of geology in the National Museum of Natural History, Paris; Dr. V. Madsen, of the Royal Library, Copenhagen; Professor P. Niggli, professor of mineralogy and petrography in the University of Zurich; Professor J. F. Pompeckj, professor of geology in the University of Berlin, and Dr. M. D. Zalessky, Leningrad, have been elected foreign correspondents.

THE University of South Carolina has conferred upon William Chambers Coker, Kenan professor of botany in the University of North Carolina, the honorary degree of LL.D.

WE learn from *Nature* that at the meeting of the Royal Society of Edinburgh held on July 6, the Makdougall Brisbane Prize for the period 1922–1924 was presented by the president to Professor H. Stanley Allen, professor of natural philosophy in the Univer-

sity of St. Andrews, for his investigations in theoretical physics, particularly for his communication to this society on the magnetic character of the quantum, and on static molecular models of hydrogen and helium.

THE Chalmers Memorial Gold Medal was presented at the recent annual general meeting of the Royal Society of Tropical Medicine to Professor Warrington Yorke, professor of parasitology in the University of Liverpool and Liverpool School of Tropical Medicine, in recognition of his work on trypanosomiasis, malaria and other subjects.

DR. WILLIAM T. HORNADAY, of the New York Zoological Society, has received the gold medal of honor that was awarded to him recently by the International Congress for the Study and Protection of Birds.

MRS. HELEN S. WRIGHT, of Pittsfield, Mass., has been elected to a fellowship in the Royal Geographic Society of London for her writings on Arctic and Antarctic exploration and history.

IN connection with the visit of the British Medical Association to Bath a congregation of the University of Bristol was held on July 22, when the degree of LL.D. was conferred upon Sir Humphry Rolleston, president of the Royal College of Physicians, of London, and Sir Berkeley Moynihan, the distinguished abdominal surgeon, of Leeds.

THE President of Ecuador has conferred the decoration "Al Mérito," of the first class, on Wilson Popenoe, of the U. S. Department of Agriculture, in recognition of his services to Ecuadorian agriculture.

DR. DE SITTER, of the University of Leiden, has been elected president of the International Astronomical Union in place of Dr. Campbell, the retiring president. The vice-presidents who now take office are Professor Cerulli, of Rome; Dr. Deslandres, of Paris; Professor Eddington, of Cambridge; Professor Shin Hirayama, of Tokyo, and Professor Schlesinger, of Yale University.

PROFESSOR F. G. DONNAN, professor of inorganic and physical chemistry at the University of London, has been elected president of the Faraday Society, England.

AT the recent meeting in San Francisco, Mr. James E. Davidson, vice-president and general manager of the Nebraska Power Co., was elected president of the National Electric Light Association.

A COMMITTEE consisting of nine men prominent in the Nebraska Power Co., was elected president of Burdick, Mr. H. E. Howe, Dr. Chas. H. Herty, Mr. Henry Howard, Mr. G. Ober, Mr. E. T. Trigg, Mr. A. Cressy Morrison and Mr. S. W. Wilder, has been asked to serve as an advisory committee to the Department of Commerce. The function of the committee is to advise the chemical division of the department as to the proper lines of endeavor for them to undertake.

C. E. SIMS, electrometallurgist, has been designated as chief of the metallurgical section at the Pittsburgh, Pa., experiment station of the Bureau of Mines, and in this capacity will have technical supervision of all metallurgical work conducted at that station.

DR. CARLETON HENNINGSEN has resigned his position with the Forest Products Laboratory of the U. S. Forest Service to join the Du Pont Fibersilk Company of Buffalo, New York, as chemist.

SIR RICHARD REDMAYNE, formerly chairman of the Imperial Mineral Resources Bureau, England, which has recently been amalgamated with the Imperial Institute, South Kensington, has been appointed director of the Imperial Institute.

THE yacht *Arcturus*, bearing the oceanographic expedition of the New York Zoological Society, with William Beebe, the naturalist, in charge, returned to New York on July 30. The expedition brought back a collection of rare fish and other sea animals. Most of the specimens were secured in the vicinity of the Galapagos Islands in the Pacific.

THE first three Harvard University students to go to the Harvard Biological Laboratory, Soledad, Cuba, under the Atkins's fellowships, J. G. Myers, George Salt and J. A. Dawson, have returned. They report good collecting and found the facilities of the new laboratory excellent. Mr. Myers worked on Cuban Hemiptera, Mr. Salt on the Hymenoptera and on Sugar Cane Borers and Dr. Dawson on Cuban Protozoa.

OTTO DEGENER, who has been spending the year at the New York Botanical Garden, studying his collections of Hawaiian plants, is returning to Honolulu.

PROFESSOR WILLIAM H. HOBBS, of the University of Michigan, is spending the summer in Europe. In September he will join Dr. Lange Koch at Copenhagen and assist in planning the scientific work of the new Danish Expedition to Greenland, which is expected to leave in the spring of 1926.

FREDERICK G. CLAPP, New York, has been studying the geological features of the eastern coast of North Island of New Zealand.

Nature states that Professor R. Ruggles Gates, professor of botany at the University of London (King's College), sailed from Liverpool on July 14, on an expedition to the Amazon region. He planned to leave

the ship at Manáos and spend a month collecting plant materials in that region and farther down the river. Returning from Para, he will reach England early in October.

A PARTY of German scientists, headed by Dr. Merz, has arrived at Cape Town in the survey ship *Meteor*, which left Wilhelmshaven on April 16 for a two years' deep sea research cruise in the Atlantic Ocean.

THE Lane Medical Lectures at Stanford University for 1925, which are to be delivered by Professor Vittorio Putti, director of the Rizzoli Institute, Bologna, Italy, will be held at Lane Hall, Stanford Medical School, San Francisco, from October 5 to 9. The subjects for these lectures are as follows: "Congenital dislocation of the hip," "Arthroplasty: History and general considerations," "Arthroplasty: Technique," "New conceptions of the pathogenesis of sciatic pain," "The University of Bologna in the history of medicine."

LUCIUS ELMER SAYRE, dean of the School of Pharmacy of the University of Kansas and formerly president of the American Pharmaceutical Association, died on June 21, aged seventy-one years.

DR. F. E. BEDDARD, F.R.S., zoologist and author, who was for many years prosector to the Zoological Society of London, died on July 14, at the age of sixty-seven years.

DR. ADOLF LAZARUS, professor of internal medicine at the University of Berlin, who collaborated in some of the important researches of Dr. Paul Ehrlich, died on July 24, aged fifty-eight years.

SENATOR GIULIO DE PETRA, the archeologist, director of the Naples Museum, died on July 24, aged eighty-five years.

A MEMORIAL to Captain Scott, R.N., and his four companions who perished in the Antarctic Expedition in 1912 was recently unveiled at Devonport, England. Captain Scott was a native of Devonport. The monument, which was designed by the late Mr. Albert H. Hodge, consists of a granite pylon surmounted by a bronze group representing "Courage sustained by Patriotism, spurning Fear, Despair, and Death." The front of the pylon bears the names of the five heroes. The total height is about 40 feet. A memorial tablet in bronze has been placed in St. Paul's Cathedral with an inscription by the late Lord Curzon: "Inflexible of purpose—steadfast in courage—resolute in endurance in the face of unparalleled misfortune—their bodies are lost in the Antarctic ice, but the memory of their deeds is an everlasting monument."

AN amendment designed to prohibit the teaching of evolution in the common schools of Georgia has been voted down overwhelmingly by the State House of Representatives.

A NUMBER of French scientists, headed by M. Paul Appell, rector of the University of Paris and member of the Academy of Sciences, have signed a formal protest against the verdict passed at the Dayton trial and the reactionary spirit which informed the proceedings. Among those who have signed the protest are: Professor D'Arsonval, of the Collège de France; Professor Aulard; Mme. Currie; M. Yves Guyot, the well-known economist; M. Ferdinand Brunot, dean of the faculty of letters of the Sorbonne; Professor Pierre Janet; Professor Paul Langevin, and M. Louis Lumière. The protest calls the Dayton trial a "violation of the liberty of thought."

THE seventieth annual meeting of the American Chemical Society took place in Los Angeles during the week of August third. Features of the first night were addresses by Dr. Alexander Findley, of the University of Aberdeen, Scotland, and by W. R. Whitney, of the General Electric Company, Schenectady, both of whom discussed modern theories of matter.

THE American Electrochemical Society will meet in Chicago on April 22, 23 and 24, 1926. Dr. H. C. Cooper has been appointed chairman of the local committee. The main session at the Chicago meeting will be devoted to a symposium on "Chlorine." Papers intended for the spring meeting must be in the hands of the publication committee not later than January 1, 1926.

A MEETING in connection with cancer research was held in Milan on July 13. Among the foreign scientists who attended were Dr. Louis W. Sambon, of the London School of Hygiene and Tropical Medicine; Dr. H. A. Baylis, Mr. K. A. Baylis, Mr. J. Ramsbottom, all three of the British Museum; Dr. T. C. Pan, of the London School of Hygiene and Tropical Medicine. The meeting was presided over by Dr. Sambon, who made a detailed report of the results so far obtained.

AN International Forestry Congress, which will continue its sitting until July 27, has been opened at Grenoble, France. It will consider all questions relating to the increased production of wood and its more rational consumption. The protection of fauna and flora will also be discussed.

AT the annual meeting of the British Empire Cancer Campaign the following grants, recommended by the scientific advisory committee, were approved: £808 to Dr. J. C. Mottram, of the Radium Institute; £500 to Mr. Hieger, at the Cancer Research Institute of the Cancer Hospital, for chemical and other researches into the cause of cancer, and a grant of £1,500 to the

Tropical Disease Prevention Association for certain investigations into the cause of cancer, and it was unanimously resolved to confirm the recommendations of Sir William Leishman's committee to establish a journal of abstracts for the purpose of assisting and coordinating cancer research work throughout the world.

Nature states that in celebration of the two hundred and fiftieth anniversary of the foundation of the Royal Observatory, Greenwich, the King and Queen paid a visit to the observatory on July 23. They were received in the octagon room, the original observatory, by members of the Board of Admiralty and of the Board of Visitors of the Royal Observatory, and were conducted over the buildings and shown the principal instruments. On the evening of the same day a conversazione was given by the president and council of the Royal Society to meet the delegates to the International Astronomical Union. On the following day an official luncheon was given, presided over by the First Lord of the Admiralty.

FOR the protection of birds and animals $60,000 has been left from the estate of Finley Barrett, of Lake Forest, Ill. Bequests of $25,000 each to the Izaak Walton League of America and the American Game Protective and Propagation Society were made and the Audubon Society of America is left $10,000.

UNIVERSITY AND EDUCATIONAL NOTES

THE trustees of the University of Tennessee have approved the contract for the first of a series of buildings for the medical college to be erected in Memphis. This building, which will cost about $350,000, will be the first step in the expansion program of the medical school made possible by recent legislation, and will house the departments of anatomy, chemistry and physiology.

THE Rockefeller Foundation has given to the King Edward the Seventh College of Medicine, Singapore, $350,000 for the endowment of chairs of bacteriology and biochemistry on condition that the government founds an extra chair of biology and agrees to equip and maintain the three departments.

DR. HERBERT BRISTOL DWIGHT, of the Canadian Westinghouse Company, has been made professor of electrical engineering in the Massachusetts Institute of Technology. In the same department Professor F. S. Dellenbaugh, Jr., has been promoted to an associate professorship, and Messrs. Bowles, Dahl and Lansil to assistant professorships.

AT the University of Colorado Dr. Aubrey J. Kemper, of the University of Illinois, has been appointed professor of mathematics and acting head of the department, succeeding Dr. Ira M. DeLong, who has been made professor emeritus after forty-seven years of service.

DR. IRVING H. BLAKE (Ph.D., Illinois), has been appointed associate professor of zoology, and Dr. Howard B. Stough (Ph.D., Harvard), assistant professor of zoology at the University of Idaho.

DR. E. G. MAHIN has resigned his position as professor of analytical chemistry and acting head of the department of chemistry in Purdue University, to become professor of analytical chemistry and metallurgy in the University of Nôtre Dame, the appointment to take effect at the opening of the college year in September.

DR. GEORGE M. CURTIS, formerly National Research Fellow in medicine, has been appointed associate professor of surgery at the University of Chicago and associate professor of experimental surgery under the Douglas Smith Foundation for Medical Research of the University of Chicago.

DR. NELSON W. TAYLOR, of the University of California, has been appointed assistant professor of physical chemistry at the University of Minnesota.

RALPH C. HARTSOUGH, of the department of physics of Columbia University, has been made professor of physics, Cornell College, Mt. Vernon, Iowa.

DR. M. P. MOON, instructor in bacteriology at Cornell University, has been appointed assistant professor of medical bacteriology and preventive medicine, at the University of Missouri.

DR. G. M. SHRUM, research physicist at the University of Toronto, has been appointed assistant professor in physics at the University of British Columbia, Vancouver.

AT the University of London J. S. Huxley has been appointed to the university chair of zoology tenable at King's College, and Dr. L. Rodwell Jones to the university chair of geography tenable at the London School of Economics.

DISCUSSION AND CORRESPONDENCE

THE ETIOLOGY OF CANINE DISTEMPER

FOLLOWING the isolation of an organism from silver foxes which would reproduce the disease known as fox distemper,[1] a search was made for a similar

[1] Green, R. G., "Distemper in the silver fox (*Culpes vulpes*)," *Proc. Soc. Exp. Biol. and Med.*, XXII: 546–548.

organism as the cause of canine distemper. In collaboration with H. O. Halvorson, studies have been carried out on the experimental transmission of canine distemper through a series of dogs.

Infective material has yielded an organism belonging to the genus Salmonella, similar to that previously described as the cause of fox distemper. This organism, isolated from cases of canine distemper and injected into well, healthy dogs, produces the clinical picture of canine distemper and the organism may be subsequently obtained in pure culture.

While it is recognized that dogs may be subject to more than one infectious disease, it is believed that the organism isolated is of great importance as a primary cause of infectious disease in dogs which is usually described as distemper.

ROBERT G. GREEN

UNIVERSITY OF MINNESOTA
MEDICAL SCHOOL

THE NAME N IN COS NT

THE note by Arthur Taber Jones in SCIENCE for June 5 suggests that n in the expression $x = A \cos(nt-\varepsilon)$ be called the *π-frequency* of the motion. Since $nt-\varepsilon$ is an angle, the phase angle, and nt the time angle, n is an angular velocity. Its unit is one radian per second—at least, that is its most rational unit—and it is more commonly and more properly written ω than n. However it is written, angular velocity is the natural and, I should say, the proper name for it. n may be left to denote 1/T, properly called the frequency. It may be objected that the term angular velocity suggests circular motion, which, in this connection, it is desirable to avoid. But, as long as one is using the circular functions, the underlying circular motion may as well be recognized. I should say that the term *π-frequency* is unnecessary and that n in the expression cos nt is, in fact, angular velocity, and might as well be called angular velocity.

W. W. SLEATOR

ANN ARBOR, MICHIGAN

IN a note appearing in SCIENCE for June 5, Professor Arthur Taber Jones has suggested the term "π-frequency" for the coefficient of time in the trigonometrical expression for simple harmonic motion. This quantity (most often denoted by ω) is commonly known to electrical engineers and text-book writers as "angular velocity." The term "velocity" in this connection has always appeared to me as a misnomer, particularly in alternating currents, where it does not correspond to any real motion. I agree with Professor Jones in the recognition that this quantity is truly of the nature of a frequency. However, I feel that the term "π-frequency" has a rather too academic flavor to be generally accepted. The term which I have used for this quantity for a number of years with my classes in electrical engineering is "angular frequency." This appears in a recently issued text-book.[1]

L. A. HAZELTINE

STEVENS INSTITUTE OF TECHNOLOGY
HOBOKEN, N. J.

HONEY BEES FOLLOW WOOD BEES FOR NECTAR

E. A. SCHWARZ and the writer made observations May 2, 1925, showing that honey bees get nectar from long-tubed corollas of bush honeysuckle (*Diervilla florida*). They tried continually to go down the tube, only to stick long before reaching the nectar. Then they would buzz around big wood bees (*Xylocopa virginica*), who did not seek to enter corolla, but crawled down outside near the tip of the sepals and punctured the corolla tube with their strong black mouth parts. Honey bees frequently followed these bees and stuck their proboscis through the large slit made by wood bees. This is another instance of *Apis mellifera* adaptability to secure nectar from flowers with tubes longer than the tongue. A war of words has raged in bee journals for some years as to how honey bees could get nectar from red clover with florets longer than bee tongues. Is it possible that they follow some other insect to punctures in floret tubes already there?

A. C. BURRILL

STATE MUSEUM
JEFFERSON CITY, MO.

TOTEM POLES

To aid me in my compilation of information about totem poles, I should be glad to receive from those institutions and individuals who have not already sent me the materials, a full list of totem poles and house posts (not models) in their charge.

I desire the catalogue number of each specimen, the name and address of the person or museum owning it, its height, the location from which it came (including its position in the village and relation to other poles) and reference to catalogue numbers of photographs and motion pictures of it, as well as to illustrations of and literature about it.

A catalogue of photographs of these objects is also desired. While complete information is sought, any clue to obscure poles will be welcome, even to poles *in situ*.

HARLAN I. SMITH

NATIONAL MUSEUM OF CANADA,
OTTAWA, CANADA

[1] L. A. Hazeltine, "Electrical Engineering," page 166.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE ULTRA-VIOLET MICROSCOPE AS EMPLOYED BY BARNARD IN HIS CANCER RESEARCHES

ACCOUNTS in the daily press regarding the work of Gye and Barnard emphasize that the discovery of the reported organism would not have been possible without the aid of a special microscope for the use of ultra-violet light, and the original article in the issue of *The Lancet* for July 18 which has just been received shows that Barnard relied chiefly on this microscope for ascertaining the appearance of the organisms under investigation.

The advantage of employing short wave lengths of light as a means of enhancing the resolving power of an objective has long been recognized and is patent upon an examination of Abbe's well-known formula for resolving power: size of smallest particle visible = $\frac{\text{½ wave length of light}}{\text{numerical aperture}}$. Without here again entering into a detailed discussion of this formula and its implications, it is to be noted the upper practical limit for numerical aperture has apparently been reached at 1.4 in the apochromatic objectives devised by Abbe. And even this aperture is not available for living objects in aqueous media, where the upper limit of the available numerical aperture is about 1.25.

The only line of progress then open towards greater resolving power would seem to lie in the direction of employing light of shorter wave lengths.

Amici already had found that a slight but appreciable gain can be achieved by employing green light. The still further gain which should be obtained by employing blue light is largely lost because of decreased visual acuity in blue. Photographic plates, however, are still sensitive at the blue end of the spectrum and even in the ultra-violet. Assuming an average wave length of 550μμ for ordinary visual light, it would be possible to practically double the resolving power of an objective by employing ultra-violet light with a wave length of 275μμ.

A. Köhler aided by M. v. Rohr, members of the scientific staff of the Zeiss Works, set about to construct a microscope for the use of ultra-violet light. Serious difficulties had to be overcome (glass is practically opaque to waves of less than 300μμ), but in 1904 Köhler published a detailed description of the completed instrument. This microscope for microphotography by the use of ultra-violet light at once received great attention and a considerable number of institutions as well as private investigators provided themselves with an equipment. For the most part, however, the results obtained did not come up to what the performance of the objectives gave a right to expect. The explanation lies close at hand. Twenty years ago microphotographic knowledge was less widely disseminated than to-day. The ultra-violet equipment not only requires familiarity with microphotographic methods but presents several additional complications which, while not difficult or troublesome to one acquainted with them, are more than most biologists were prepared to handle. Since then much has changed. Biologists have become accustomed to handling elaborate equipment, and it is to be expected the ultra-violet microscope before long will be yielding results in the hands of biologists commensurate with its capacity.

It is essentially the Köhler ultra-violet microscope which Barnard employed in his researches. Mechanically he made some modifications in the equipment which were intended to increase the rigidity of the microscope and to provide for more delicate focusing. In this Barnard followed the well-known British penchant towards massive and complicated microscope stands. Without questioning the good services which Barnard's stand is rendering its inventor, it may well be doubted whether its employment in other hands would be of advantage. There is greater opportunity for getting the parts out of alignment in this modified microscope. It was precisely one of Köhler's aims in constructing his equipment to have the arrangements such that as little opportunity as possible be given for dis-adjusting the parts while at the same time providing convenient means for such movements as are necessary. As for stability and precision of focusing, the writer from long-continued use of several of Köhler's outfits can testify that he never encountered the slightest need of greater refinements in these directions.

Barnard also employed an ingenious combination condenser, used alternately for darkfield illumination with visible light and for microphotography with ultra-violet light. For general use, however, it would seem a sounder procedure to employ for darkfield studies a separate darkfield outfit. As a finder for minute objects to be photographed by means of ultra-violet light, the darkfield combination is of questionable value. It is probably simpler and fully as effective to employ as a guide markings or objects of an appropriate size for ready detection scattered among the more minute structures. Barnard, himself, has called attention to and used this method (droplets of mercury sublimated on to the quartz slide).

Finally, a word as to the prospects for using light of still shorter wave length. There is no special difficulty in correcting objectives for wave lengths between

275 and about 200μμ (where the absorption of air and quartz becomes troublesome). It is not easy, however, to obtain a sufficiently intense and at the same time sufficiently monochromatic source of light for these shorter wave lengths and it is questionable whether the theoretical gain in resolution achieved by passing from 275μμ to say 225μμ would be realized in practice. Barnard employed an objective with light of wave length 257μμ and reproduces a photograph taken with this combination. From a comparison of this photograph with another taken with 275μμ, it is not at all certain that the differences are due to increased resolution on account of the shorter wave length rather than to adventitious circumstances.

If a further step is to be taken, it may well be best to pass directly into the region of Schumann rays. But for the present the possibilities of the equipment for ultra-violet light of 275μμ have not yet been fully utilized and the most promising results seem to be in sight through its more thorough use. Much is to be expected in this respect in the near future. A number of biologists are at present successfully using the apparatus and its use has also been extended to metallography (opaque objects) where it is opening up an entirely new field.

W. MARQUETTE

PLEASANTVILLE, NEW YORK

SPECIAL ARTICLES

THE HYDROPHILIC EFFECT OF IONS ON AGAR AND PROTOPLASMIC COMPONENTS

PROFESSOR L. MICHAELIS says in his recently published American lectures on the effects of ions on colloidal systems:[1] "One can not talk of *the* hydrophilic effect of ions. In different cases different kinds of effects become manifest." This pronouncement was made with especial reference to conclusions of Loeb, based chiefly on experiments with gelatine, that the differential action of ions as expressed in the Hofmeister series does not hold. Michaelis was led to make this cautionary statement because numerous experiments in his own laboratory have shown that the series is valid in the hydration of agar in neutral salt solutions through a certain range of concentration. Scores of workers have shown that the lyotropic series *is* apparent when dealing with living cell-masses and the results of the senior author prove that it runs through the hydration reactions of agar and agar-protein mixtures, and that the differential action of univalent anions as well as kations is demonstrable in the artificial cell constructed of these materials.

It is to be noted that even Professor Michaelis does not realize the full force of his cautionary statement. Relying upon results of van Kruyt, de Jong and Dokan, he says:

> When a piece of agar jelly is put into water or an aqueous electrolyte solution, swelling occurs and the weight attains a constant value after about one day's swelling. The degree of swelling can be measured very exactly, and the swelling is found to be most pronounced when agar is exposed to pure water.[2]

Specifically this statement may be connected with some recent results by Dokan,[3] whose method was to dry a 2 per cent. agar gel to one third its original thickness, then allow it to swell twenty-four hours. Changes were determined by weight. Obviously only a narrow sector of the hydrating action was measured, and the data thus obtained might be expected to yield no fine distinctions. These, however, were sufficient to show that Loeb's generalizations as to the invalidity of the Hofmeister series would not hold. By this gross method univalent kations were equivalent in their effects in concentrations below 0.1 N, but the Hofmeister series was evident above this. A more exact method would have extended the series to extremely dilute solutions.

This has been done repeatedly in this laboratory during the last decade by a method in which 2.5 per cent. warm agar solutions, which cast as plates cool, set as a firm jelly and dry down to a thickness of 0.1 to 0.5 mm, according to the thickness of the original, and which in a freshly air-dried condition at 15° have a water content of about 25 per cent. Trios of small sections with surfaces of 8 to 10 sq. mm, and a volume of 2 to 5 cu. mm, were placed in a Stender dish covered with a triangular piece of glass plate on the center of which a vertical arm of an auxograph had a bearing. About 50 ml. of solution was poured in each dish and resultant swelling was recorded for a week or as much longer as desirable with daily replacement of the solution. Determination of losses by solution from the sections showed a loss of one seventh of the dry weight of such sections immersed in water during the first twenty-four hours. Such losses by solution do not appear to have been taken into account by workers who obtain data as to swelling by weighing the sections. It will be noted that if auxographic records were corrected for such

[1] Baltimore, 1925, Williams and Wilkins Company (see p. 97).

[2] *Ibid.*, p. 88 and Fig. 2.

[3] Dokan, Von S.: Die Wirkung der Elektrolyte auf die Quellung der Agar. Kolloid. Zeitschrift, *34*, 155 (1924).

losses, the excessive increases of agar in dilute solutions would be accentuated.[4]

The results illustrate in no uncertain manner that the chlorides of Na, K. Ca and Mg. at concentrations from 0.001 to 0.0001 M cause an excessive hydration of such sections of agar, that the effects of the kations are distinctive, and the differential effects of the anions, nitrate and sulphate, are also apparent. Excessive swelling was found by the use of HCl 0.0001 N, and in weak hydroxides, while still more marked effects were secured with solutions of amino-compounds such as glycocoll, histidine, phenyl-alanin, asparagin, alanin, etc.[5] These increases took place in the various solutions under a total range from Ph. 4.2 to Ph. 11. Mixtures of agar and gelatine also showed a great increase over that in water, especially in amino compounds.

Fairbrother and Mastin,[6] apparently unacquainted with these results, published similar data with regard to the effect of the common acids and alkalis on the swelling of agar.

Dokan's experiments dealt with the agar gel through only a third of the total range and took no account of losses by solution. Consequently the differential effects were lost and diminished totals found. The auxographic measurements recorded hydration increases of agar plates from a fresh air-dry condition at 15 to 20° C. to approximate satisfaction. The increased delicacy and effectiveness of this method extends the differential effects of kations and anions to extremely dilute concentrations. The range of swelling followed in such measurements is four times as great as in the method of Dokan, which was that employed by many workers. The measurement of the changes in volume of an agar plate from the air-dry condition in which it holds one fourth its weight in water to one in which it holds as much as forty times its volume of water doubtless comprises the changes in such a reversible gel of direct biological interest. It is by no means, however, the whole story of the hydration of agar.[7] If the water content of agar plates be reduced to a minimum by drying still further in a desiccator over phosphorus pentoxide, it will be found that their hydration capacity has been reduced so that an increase of only a few hundred per cent. is exhibited when they are placed in water as determined by weighing. In what manner the differential effects of kations would be shown if such desiccated material were placed in solutions of electrolytes is not known.

Professor Michaelis cites some hydration reactions of Konyaku, a polysaccharide of mannose and glucose obtained from the tubers of *Amorphophallus Konaku* measured by Dokan, which does show excessive and differential swelling in solutions of some electrolytes and hydroxides, but not in others. These comparative effects are reminiscent of the hydration increases of agar-gelatine mixtures in suites of solutions and suggest that the substance in question will be found to include a relatively high proportion of proteinaceous material: Glycolipins may also be present.

The results of scores of workers show that the action of ions on colloids, and consequently on permeability of walls and plasmatic layers, are not to be accounted for solely by electrostatic effects, determined by sign and valency. Such effects are due to the direct action of ions on colloidal particles. Differential or lyotropic effects among univalent ions, for example, are to be attributed to the varying attraction of the different elements for water molecules, thus exerting an indirect effect on the hydration of the colloidal particle, as is well described by Professor Michaelis, who suggests that the nature of such attraction depends on atomic radius. As noted above, he believes these effects are not seen at low concentrations, except in the case of the hydrogen ion. The results cited in this note establish well-marked differential action of common univalent and bivalent ions at extremely low concentrations in conformity with the lyotropic series, and give greater value to the proposal of Michaelis as to the physical basis of such effects.

D. T. MACDOUGAL
B. L. CLARKE

DESERT LABORATORY

[4] MacDougal, D. T., and Spoehr, H. A.: "The solution and fixation accompanying swelling and drying of biocolloids and plant tissues." *Plant World, 22,* 129, May, 1919.

[5] MacDougal, D. T.: "Auxographic measurements of the swelling of biocolloids and of plants," *Bot. Gaz., 70,* 126, 1920; "Action of bases and salts on biocolloids and cell-masses," Proc. Amer. Phil. Soc., *60,* 15, 1921; and Spoehr, H. A., "The components and colloidal behavior of plant protoplasm," 59, 150, 1920.

[6] Fairbrother and Mastin, Trans. Chem. Soc., *123,* 1412 (1923).

[7] Clarke, B. L., *Journ. Amer. Chem. Soc., 47,* 7, (1925).

THE AMERICAN CHEMICAL SOCIETY

DIVISION OF BIOLOGICAL CHEMISTRY

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The fate of intarvin in the normal and diabetic economy: MAX KAHN and HATTIE L. HEFT. Intarvin, the synthetic neutral odd-carbon fatty-acid fat (glyceryl trimargarate), is absorbed in the animal organism to the extent of about 95 per cent.; and upon catabolism yields

approximately eight calories of heat per gram of fat. It is oxidized in the normal and diabetic organism without the production of beta-oxy-butyric acid, diacetic acid, acetone or alpha or beta lactic acids. It thus lends itself to the feeding of diabetic individuals, in quantities sufficient to bring up the total caloric intake to a maintenance diet. Five successive generations of rats have been fed with intarvin as one of the main food ingredients, with no observation of any toxic or detrimental effects. The successive generations are normal in size, weight and behavior. Studies are now under way to determine the nature of the fat deposited.

Some chemical properties of vitamine B: ATHERTON SEIDELL. The picric acid present in the antineuritic picrate, prepared from brewers' yeast by the method previously described, can be quantitatively removed with the aid of nitron. The resulting free base retains the antineuritic properties of the picrate. It protects pigeons from loss in weight on polished rice in daily doses of 43 milligrams. The activity is not destroyed by drying in a vacuum at moderate temperature. The molecular weight of the base, determined by lowering of the freezing point of acetic acid, is 201. Combustion analyses give results corresponding to the formula $C_8H_{15}O_3N_3$. When titrated with acid, using methyl red as indicator, a fairly sharp end-point occurs at approximately one molecule of acid to two of base. A Van Slyke determination shows one amino nitrogen.

A contribution to the chemistry of grape pigments. IV. The anthocyans of Isabella grapes: R. J. ANDERSON and FRED P. NABENHAUER. The anthocyans occurring in grapes, so far as determined, are glucosides of methyl delphinidin. American grapes contain mainly delphinidin monomethyl ether, while *Vitis vinifera*, as well as hybrids of American varieties with vinifera, contain principally the dimethyl ether. Isabella grapes (labrusca × vinifera) contain delphinidin dimethyl ether as a monoglucoside. The anthocyanin crystallizes in prisms and is identical with oenin. When hydrolyzed with hydrochloric acid, the glucoside yields glucose and anthocyanidin chloride, identical with oenidin chloride. Oxidation of the acetyl derivative of oenidin gives acetyl syringic acid and by hydrolyzing the latter syringic acid is obtained. This fact is of importance in determining the constitution of oenidin.

Reactions of bb dichlorethyl sulphide with compounds containing amino groups: WALTER E. LAWSON and E. EMMET REID. This comprises an investigation of the reactions of bb dichlorethyl sulphide, sulphoxide and sulphone with primary, secondary and tertiary amines and direct condensation of the sulphone with two amino acids, in an effort to obtain information bearing on a "condensation" theory of vesicant action, that is, the disturbing of the equilibrium maintained within the cell by a reaction between the toxic compound and portions of the protein molecule. Thirty-six new compounds, exclusive of hydrochlorides or platinum salts, were prepared, and several new series of compounds were discovered. The evidence secured was not opposed to the theory.

The physiologic properties of some unsaturated hydrocarbons: LLOYD K. RIGGS. Hydrocarbons of the olefine, acetylene and diolefine series have been administered to white rats by inhalation, and the anesthetic potency and toxicity of each hydrocarbon has been determined. Ethylene 90 per cent., propylene 40 per cent., butylene 20 per cent., amylene 6 per cent. and acetylene 78 per cent. induce anesthesia in 15 to 18 minutes. Propadiene 20 per cent. and methylacetylene 5 per cent. produce prostration, not true anesthesia, in 15 to 18 minutes. Propylene 65 per cent., butylene 20 per cent., amylene 6 per cent, acetylene 90 per cent., methylacetylene 5 per cent. and propadiene 15 per cent. cause respiratory failure in about two hours. The potency and toxicity of each hydrocarbon has been related in the form of an index thus: $\frac{\text{Potency} \times 100}{\text{Toxicity}}$ = Anesthetic Index. The anesthetic indices of propylene, butylene, amylene and acetylene are 100, 61 and 71, respectively.

Studies of the physiologic action of propylene: HAROLD D. GOULDEN and LLOYD K. RIGGS. The time in which various concentrations of propylene induce analgesia, anesthesia and respiratory failure has been measured. A number of mixtures of propylene, oxygen and nitrogen were made up in different proportions and tested for anesthetic effect. The time required to produce analgesia, anesthesia and finally respiratory failure was measured. The results indicate that propylene is a potent anesthetic which possesses a wide margin of safety.

Physico-chemical studies on proteins. II. Alkali binding. A comparison of the electrometric titration of proteins and of phosphoric acid with sodium and calcium hydroxides: WALTER F. HOFFMAN and ROSS AIKEN GORTNER. H_3PO_4, casein and durumin have been titrated electrometrically with NaOH and $Ca(OH)_2$ and "back titrated" with HCl. The alkali titration curve of casein resembles that of a weak acid, such as NaH_2PO_4, while that of durumin resembles much weaker acids. NaOH and $Ca(OH)_2$ give the same type of curves with proteins but not with H_3PO_4, where both the secondary and tertiary hydrogens are replaced by calcium at the pH at which Na_2HPO_4 is formed. The difference between the alkali $^\circ$ H_3PO_4 or protein and alkali + H_3PO_4 or protein + HCl curves is shown to be due to $Ca_2H_2(PO_4)_2 + 4HCl = 2CaCl_2 + 3H_3PO_4$ not going to completion.

A study of the effect of the concentration of sodium carbonate in the Benedict quantitative sugar method: ARMAND J. QUICK. The glucose equivalent of Benedict's quantitative sugar reagent is found to be markedly influenced by the concentration of sodium carbonate. A minimum and constant value is obtained when the final concentration of sodium carbonate exceeds 25 g per 100 cc; below this concentration the glucose equivalent increases as the sodium carbonate decreases. The minimum and constant value of the reagent prepared according to the

directions of the author is found to be 1.88–1.90 mg of glucose per cc instead of 2.0 mg, the value now used.

The effect of additions of fluorine to the diet of the rat on the quality of the teeth: E. V. McCOLLUM, NINA SIMMONDS and J. ERNESTEIN BECKER. The addition of 220 parts per million of fluorine in the form of sodium fluoride to a diet which produces good bones and teeth was sufficient to cause pronounced damage both to skeleton and dental structures. The persistently growing incisors in the rat were especially damaged. Being soft and chalky, the lower teeth wore to the gum line and from lack of attrition the upper ones grew into grotesque shapes.

Further studies on the cause of ophthalmia in rats produced with diets containing vitamin A: E. V. McCOLLUM, NINA SIMMONDS and J. ERNESTEIN BECKER. An intensive study designed to analyze the problem of factors concerned in producing ophthalmia by diets containing excessive amounts of inorganic elements in the presence of sufficient vitamin A indicates that no single element is responsible. Experimental conditions were devised under which the appearance of ophthalmia was determined by the vitamin B content of the diet. The interpretation of the results is complex, and reference must be made to the original publication.

The action of sodium phosphate on hexose sugars: H. A. SPOEHR and PAUL C. WILBUR. Solutions of hexose sugars in the presence of disodium hydrogen phosphate undergo mutual conversion resulting in an equilibrium mixture of aldoses, 2-ketohexoses and 3-ketohexoses. The rate of change depends upon the concentration of sodium phosphate and the temperature. With sodium phosphate there is no indication of saccharinic acid formation from the sugars, nor is there any evidence of polysaccharide formation. At lower temperature (38°) the action of sodium phosphate is confined to the interconversion reaction, while at higher temperature (70°) there is evidence of more complex reaction of the sugar molecule and the phosphate.

A further report on cholesterol and phytosterol activated by irradiation: A. F. HESS and MILDRED WEINSTOCK. Irradiated cholesterol prevents rickets when given subcutaneously. It is of value when animals are fed a ration low in calcium or low in phosphorus. Experiments with selective filters demonstrated the wave-lengths of ultra-violet which are able to bring about activation. Human or calf's skin can be rendered antirachitic by irradiation, owing to their cholesterol content. Dihydrocholesterol, dihydro-phytosterol and certain unsaturated terpenes were of no protective value following irradiation. Spectrograms of the various irradiated substances showed an alteration in transmission which paralleled their biological activity.

The influence of the bacterial flora on the biological test for vitamine B: V. G. HELLER, C. H. McELROY and BERTHA GARLOCK. Steenbock, Sell and Nelson demonstrated that the growth periods of rats fed on a vitamine free diet was considerably prolonged when they had access to their feces. Various investigators have found certain microorganisms to be synthesizers of vitamines. We have attempted to find that the prolonged growth period might be due to the presence of such organisms in the intestinal flora. Rats were divided into lots. The first placed on shavings, the second on screens and others on screens with access to various types of roughage; all were fed rations deficient in vitamine B. Examinations of the feces from the various lots show that the spore-forming organisms present vary directly with the observed extension of the growth period, disappearing from the feces somewhat prior to the time that growth ceases. These organisms have been cultured and grown upon vitamine free media and their vitamine content measured to verify the theory.

A chemical and nutritive study of the grain sorghums: V. G. HELLER and ROBERT A. GREENE. The grain sorghums thrive in the semi-arid cattle country of the southwest, where corn can not be raised. Considerable argument exists in regard to their feeding value. A few nutritive studies have been made of isolated varieties by different investigators with contradictory evidence in regard to the vitamine and protein content. Our chemical and nutritive studies of twenty-two members of the family show small individual variations. The proteins are of high quality, but like corn are deficient in certain amino acids. These deficiencies may be overcome by the addition of small amounts of certain goods, the resulting ration then produces normal growth, reproduction and successful rearing of young through at least three generations. A complete study of the vitamine contents are reported. Its wider use for feeding should be recommended.

Soft pork and its causes: J. O. HALVERSON and EARL HOSTETLER. The problem of what constitutes soft pork is discussed. Methods of investigations are given. The ration fed is the largest factor causing soft pork. This may be divided into two classes: (a) the "softening" ration, which is high in protein and in oil, and (b) the "hardening" ration, which does not contain a high percentage of oil but consists chiefly of starch. The "softening" rations of the south, which are largely high in protein and in oil, are the peanut and the soy bean. The cereal rations of the north are the "hardening" rations. These consist chiefly in starch or carbohydrates.

Results of soft pork investigations: J. O. HALVERSON and EARL HOSTETLER. The effect was studied of various methods of feeding hardening and softening feeds, especially the peanut, and Brewer's rice, which consists chiefly of starch with very little ether extraction. Equal total amounts of oil were fed individually throughout to each pig. To some were given equivalent amounts of starch (as Brewer's rice) at the same time. To others the oil-feeding period was followed by the Brewer's rice.